

EXPERT CONTRACT

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REPORT

Authors: Tommaso Russo, Matteo Stefani

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Introduction

Since 1 January 2025, the transitional phase of the West Med EU multiannual management plan (EU Regulation 2019/1022, the “MAP”) to achieve F_{MSY} has ended, and the MAP has entered its long-term and permanent implementation phase. As per Articles 21 of the MAP, Article 4 and Article 6(1) shall apply from 1 January 2025. Article 4 details how the F_{MSY} ranges operate and the flexibilities given in the context of mixed-fisheries while accounting for the safeguards outlined in Article 6.

In October 2025, EWG 25-11 was conducted between 6 and 10 October to assess various management scenarios and provide best available scientific advice in the context of the Fishing Opportunities for 2026 in the Mediterranean Sea. This Expert Working Group (EWG) builds on preliminary work conducted in STECF EWG in previous years and during discussions in STECF PLEN 25-01 and 25-02.

The work of the two *ad hoc* contracts behind this document was to apply the SMART model (Russo et al., 2014; D’Andrea et al., 2020) based on all available data and scenarios provided to EWG 25-11. The SMART model has historically been used, in the context of various EWGs Fishing effort regime for demersal fisheries in West Med, to simulate the potential effects of different management scenarios in EMU2, with particular reference to scenarios based on the implementation of spatial measures.

Terms of Reference for the Ad-Hoc contract EWG 25-11

The objectives of the TORs are to build fishing effort scenarios, coupled with catch limits and other complementary measures, that will ensure achieving and maintaining MSY for all Western Mediterranean demersal target stocks in the new context of using the F_{msy} ranges developed by EWG 24-02 and those updated in EWG 25-09. Based on previous work from available literature, including STECF reports and on the feedback and additional information received from Member States, stakeholders and STECF chairs, the contractor is requested to:

- **TOR 1.** Using the complete sets of annual data on fishing effort for all demersal fishing gear from 2015 to 2024 and the other outputs developed in EWG 25-11, develop effort and catch management scenarios for all demersal fishing gear (e.g. bottom trawls, nets, longlines) in EMU2. Scenarios should account for the management measures adopted since 2020 in the context of the Western Mediterranean multiannual management plan, in particular those under the compensation mechanism. The scenarios aim at identifying and evaluating the best levels of management measures to ensure that the stocks concerned shall be within the F_{msy} ranges (or F levels from EWG 24-02, EWG 24-10 or EWG 25-09) as soon as possible. Scenarios should follow the new legal provisions stemming from the West Med MAP, notably the use of F_{msy} ranges (Art 4 and 6 of the MAP) following Table 1 in the ToR of EWG 25-11. Requested

management scenarios, including the compensation mechanism implemented in 2022, 2023, 2024 and 2025, are provided in Table 2 in Annex of the ToRs of EWG 25-11 as well as the references to the legal texts adopted for the implementation of EU-level and national management measures in place since 2020. For stocks below Bpa and Blim, the EWG should test the effects, measured in terms of reduction in F and in catch, of the conservation measures for the stocks listed in Table 1 and identified in Table 2 of the ToRs of EWG 25-11.

- **TOR 2.** After the above simulation work, the contractors shall draft a short report (40-page max) including a comprehensive analysis of the socio-economic impacts of the proposed management scenarios, incorporating available data, including, but not limited to, data resulting from the 2024 ad-hoc contract for Italy. The socio-economic indicators should consider the potential effects on gross profit margins, or GVAs and employment levels within the demersal fishing fleets, providing valuable insights for the overall socio-economic sustainability of the sector.

Set up of SMART for EMU2

For this *ad hoc* contract, the input data sets were updated to December 2024 and the resources shared by the EWG 25-11 experts, including updated stock objects, were used. A customised version of the workflow available under the “smarR” package (D’andrea et al., 2020) was set up to model the demersal fisheries in the EMU 2 and employed to carry out the simulations required by the Commission for the EWG 25-11.

Workflow

The SMART model, as well as the workflow of the smarR package, can be summarised in the following logical steps, divided into three groups (SET UP; SCENARIO SIMULATION, STOCKS CONDITION FORECAST):

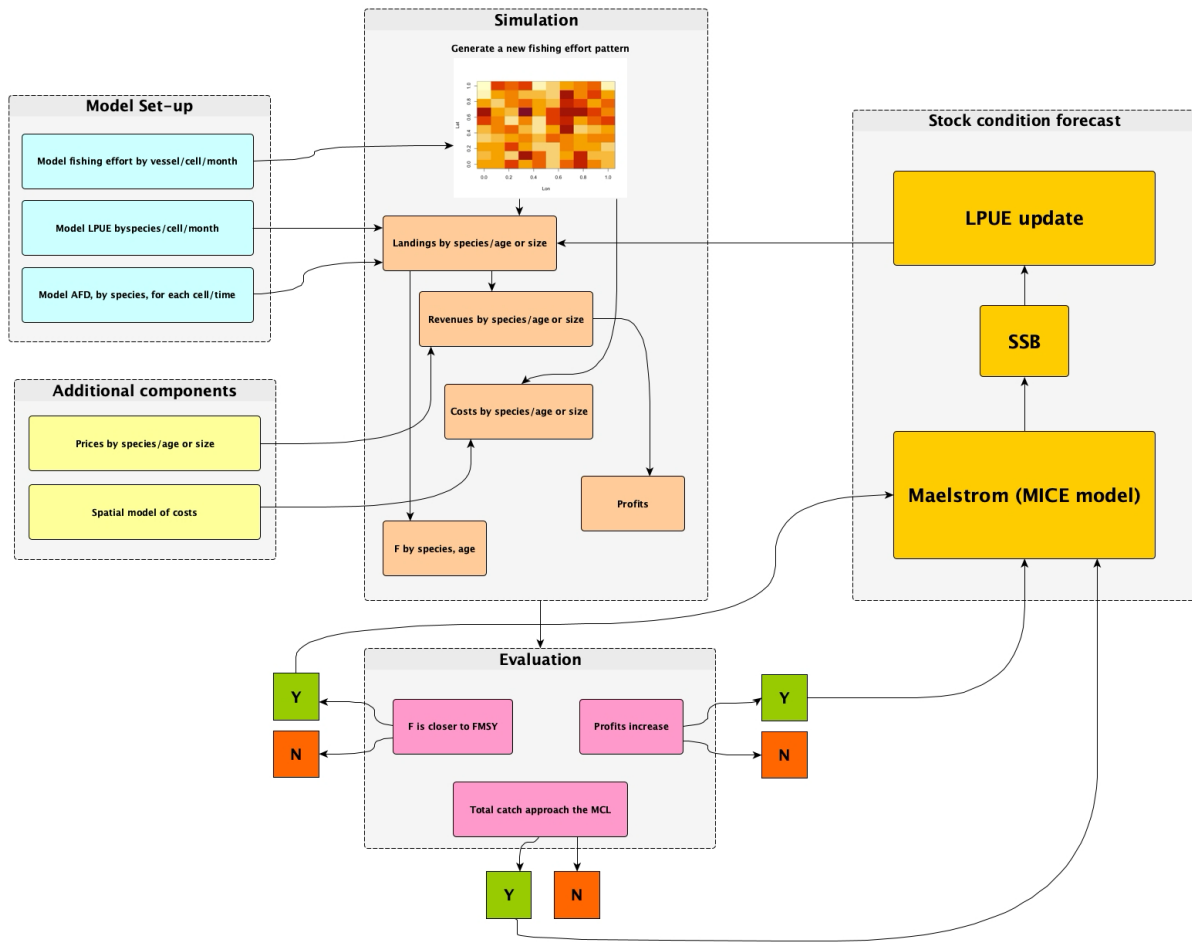
- 1 **SET UP:** Use landings and catch data, combined with VMS data, to estimate the spatial/temporal productivity of each cell, in terms of aggregated LPUE by species. The methodology for this phase is described in [Russo et al., 2018](#);
- 2 **SET UP:** Estimate the Length-Frequency Distribution (LFD) and the Age-Frequency Distribution (AFD), by species, for each cell/time, using Biological sampling of catch (CAMPBIOL) data;
- 3 **SET UP:** Use VMS data to assess the fishing effort by vessel/cell/time;
- 4 **SET UP:** Combine LPUE, LFD/AFD, and VMS data to model the landings by vessel/species/length class/time;
- 5 **SET UP:** Estimate the cost by vessel/time associated with a given effort pattern and the related revenues, which are a function of the landings by vessel/species/length class/time. The methodology for this phase is described in [Sala et al., 2022](#);

- 6 **SET UP:** Combine costs and revenues by vessel, on a yearly scale, to obtain the profit that proxies the vessel performance. Incomes could be aggregated at the fleet level to estimate the overall performance. The methodology for this phase is described in [Sbrana et al., 2025](#);
- 7 **SCENARIO SIMULATION:** Starting from the observed fishing effort pattern by vessel (amount of effort by vessel/cell/month), SMART generates new potential pattern, according to the characteristics of the desired scenarios, using a Monte-Carlo approach;
- 8 **SCENARIO SIMULATION:** Then, SMART estimates, for the new exploitation pattern (i.e. the landings by species/age):
 - 8.1 The corresponding expected landings, costs, revenues and, finally, GVA;
 - 8.2 The Fishing mortality (by species and age) for the new exploitation pattern (i.e. the landings by species/age);
- 9 **SCENARIO SIMULATION:** Each newly generated potential pattern is evaluated in terms of GVA, and accepted (if GVA increased) or discarded (if GVA decreased). In cases where the scenario requires additional measures (e.g. catch limits or F close to F_{MSY}), the new pattern is also evaluated in terms of “getting closer” to the required conditions. If, under the starting conditions, the total catch exceeds the limit set by the maximum catch limits, the new effort pattern generated is accepted only if it results in a reduction in catch for the species subject to the catch limits. This implies that, progressively, the effort patterns generated for individual vessels result in a decrease in the overall catch of the fleet. This rationale is also applied when the scenario requires, for instance “a reduction of the fishing mortality that secures F_{msy} in 2025 for all stocks”. In fact, when the target is a value of F that approach F_{MSY} , the newly generated potential pattern is accepted only if it is closer to the target than the previous value. As the simulations continue, the targets set can be achieved (but this is not always possible). In summary, SMART does not allow mortality or catch values to be set *a priori*; rather, it relies on an iterative simulation/assessment procedure that, based on the constraints set for different scenarios, aims to identify acceptable solutions.
- 10 **SCENARIO SIMULATION:** The simulation ends when one of the following conditions occurs:
 - 10.1 estimated profits for each individual boat do not improve for $N = 100$ successive generations;
 - 10.2 The overall length of the simulation exceeds a set limit. In the case of EWG 24-12, this value was set at 5,000 generations.
- 11 **STOCKS CONDITION FORECAST:** Use these fishing mortalities, together with survey data, to run a MICE model in order to obtain a biological evaluation of the fisheries.

This workflow ([Figure 1](#)) allows for the simulation of the potential adaptation of fishers, in terms of fishing effort displacement in space and time, to different management measures,

including fisheries-restricted areas and temporal stops of the fishing activity. Given that a new fishing effort pattern corresponds to new catches and related revenues, cost and, ultimately, GVA, SMART forecasts the biological and economic consequences of different management scenarios. Therefore, in SMART, the effort displacement resulting from the scenario simulation is obtained according to an individual-based optimisation of the observed pattern of effort of each fishing vessel following a strategy of profit maximisation.

Figure 1. Workflow of the application of SMART for the EWG 24-12.



In essence, for each individual fishing unit, SMART tries to predict the new activity pattern (fishing effort per cell/time) based on the profit analysis (defined by the combination of revenues and costs) associated with each possible new effort pattern. Effort patterns are generated for each vessel using a Monte-Carlo approach. The spatial productivity (monthly LPUE as grams of catch per meter of LOA and hour of fishing) was estimated using logbooks, landings and VMS data, according to the procedure of [Russo et al., 2018](#) and [Russo et al., 2019](#). After the estimation of the monthly LPUE by species, and the “historical” behaviour of each vessel (proportion of its effort for each cell of the spatial grid).

Species and Stocks

The model developed for the previous EWG has been updated to better represent the species exploited by trawlers in the EMU2. Namely, monthly LPUEs were computed for the species in [Table 1](#).

It is important to notice that while all the 12 species listed above were considered in the optimisation phase, only the stocks in the MAP were considered. The stock objects of the EWG 24-12, for the species in MAP, were integrated and processed using Maelstrom (Stefani et al., under review). Actually, the Long-Short Term Memory (LSTM) network of Maelstrom was fed with the time series of catches in number of individuals by age class, SSB by year, and abundance at sea in number of individuals by age class and trained by species to fit the historical time series. Then, the LSM was used to predict the future trends of SSB and abundance at sea as the number of individuals by age class using the new catch pattern, as obtained after the fishing effort adaptation/displacement estimation.

Table 1. Species considered within the model.

Species	FAO 3-alpha code
<i>Aristeus antennatus</i>	ARA
<i>Aristaeomorpha foliacea</i>	ARS
<i>Sepia officinalis</i>	CTC
<i>Parapenaeus longirostris</i>	DPS
<i>Eledone cirrhosa</i>	EOI
<i>Eledone moschata</i>	EDT
<i>Merluccius merluccius</i>	HKE
<i>Mullus surmuletus</i>	MUR
<i>Mullus barbatus</i>	MUT
<i>Nephrops norvegicus</i>	NEP
<i>Octopus vulgaris</i>	OCC
<i>Illex coindetii</i>	SQM
<i>Lophius piscatorius</i>	MON
<i>Squilla mantis</i>	MTS
<i>Boops boops</i>	BOG
<i>Trachurus trachurus</i>	HOM

Economics indicators

Starting from the Gross value of landings estimated by SMART, the following economic indicators were computed for the reference years of each simulation:

- Gross Valued Added (GVA)
- Gross Profit (GRP)
- Gross Profit Margin (GPM)
- Full-Time Equivalent (FTE)
- Gross value of landings
- Energy costs

The EMU2_EconomicData by GSA shared during the EWG 25-11 were as reference for tuning and validation.

The SMART model used for EWG 24-12 is parameterised based on a diversity of data sources:

- The 2024 FDI data tables I (Spatial effort), H (spatial landings), and G (aggregated effort) were used to establish the gears to be considered;
- The 2023 AER data-informed economic indicators per vessel or unit of effort per fleet segments.

Management scenarios considered

Due to time constraints, some of the scenarios defined in EWG 25-11 were not examined and simulated. The scenarios that were examined are shown in [Table 2](#).

[Table 2](#) - Management Scenarios for FO2026

Scenario for 2026 and beyond	Trawler effort levels to achieve F_{MSY} of most vulnerable stock	Compensation Mechanism for trawlers	Catch Limit for HKE levels As well as Effort level (fishing days) for LLS	Catch Limit level for ARS and ARA	Conservation Measures (Spatial)	Conservation Measures (Selectivity)
Status Quo (SQ)	Same effort in 2026 as in FO2025	Same level of compensation in 2026 and beyond as in 2025	Levels of 2025	level of 2025	keep closure areas adopted until 2025 (see Annex A)	2025 implementation: Full ES fleet, 2 thirds of FR fleet
A Fmsy in 2026 and beyond from trawling effort reduction only	2026: level of reduction that secures F_{MSY} in 2026 and beyond for all stocks (based on most vulnerable stock in each EMU)	A1. 2026: 50% of compensation gained in 2025 implementation and same for 2027 and onwards	Levels of 2025	Level of 2025	keep closure areas adopted until 2025 (see Annex A)	2025 implementation: Full ES fleet, 2 thirds of FR fleet
		A2. Same level of compensation in 2026 and beyond as in 2025 ^[AD2]				
D 12-month deep closures	2026: level of reduction that secures F_{msy} in 2026 and beyond for all stocks (based on most vulnerable stock in each EMU)	D1. 2026: 50% of compensation gained in 2025 implementation and same for 2027 and onwards	Levels of 2025	Level of 2025	closure areas adopted until 2025 (see Annex A) with in addition an increase of 12-month closure areas for trawlers to deeper waters (depths depending on stocks biology)	2025 implementation: Full ES fleet, 2 thirds of FR fleet
		D2. Same level of compensation in 2026 and beyond as in 2025				

E 5% 12-month closures in waters between 200m and 500m	2026: level of reduction that secures F_{msy} in 2026 and beyond for all stocks (based on most vulnerable stock in each EMU)	2026: 50% of compensation gained in 2025 implementation and same for 2027 and onwards	Levels of 2025	Level of 2025	Closure areas adopted until 2025 (see Annex A) with in addition an increase to <u>5% of the fishing grounds between 200m and 500m</u> closed for 12-month for trawlers	2025 implementation: Full ES fleet, 2 thirds of FR fleet
F catch limits	2026: level of reduction that secures F_{msy} in 2026 and beyond for all stocks (based on most vulnerable stock in each EMU)	(Same level of compensation in 2026 and beyond as in 2025)		2025: level of reduction that secures F_{MSY} in 2026 for ARA and ARS	keep closure areas adopted until 2025 (see Annex A)	2025 implementation: Full ES fleet, 2 thirds of FR fleet

It is important to specify that, in the case of Scenario E, the definition provided in the TORs (“*n increase to 5% of the fishing grounds between 200m and 500m closed for 12-month for trawlers*”) was implemented using the Core Fishing Ground Analysis developed within ICES (https://github.com/ices-taf/MBCG_trade-off) and applied to Mediterranean case studies in [Sbrana et al., 2025](#). The use of spatial economic variables, particularly GVA, allowed for the identification of Core Fishing Ground in the range defined by the depths 200 and 500m. The smallest region needed to maintain 95% of current GVA was identified as the core fishing grounds, using the methodology proposed by [Ban and Vincent \(2009\)](#) and [Fabbri et al. \(2023\)](#), which uses a simulated annealing process to find the least expensive solution to an objective function. The procedure is based on the ‘prioritizr’ package in R ([Hanson et al., 2023](#)).

Results

Fishing mortality

Figure 2 shows, using the layout defined during the previous EWGs, the predicted trend of F from the application of SMART.

In the case of ARS, fishing mortality is expected to decrease in all scenarios, but especially in Scenario D600, which seems to protect the stock almost completely, with an F value very close to F_{MSY} . The other scenarios follow, leading to very similar F values (but still higher than F_{MSY}). The scenarios with the smallest reductions in mortality for this stock are the *Status Quo* and Scenario E. The situation is the opposite for DPS: it is precisely the *Status Quo* and Scenario E that determine the greatest reductions in F . On the contrary, Scenarios D and F are those that could lead to small increases in F , which would return to values close to those of 2020.

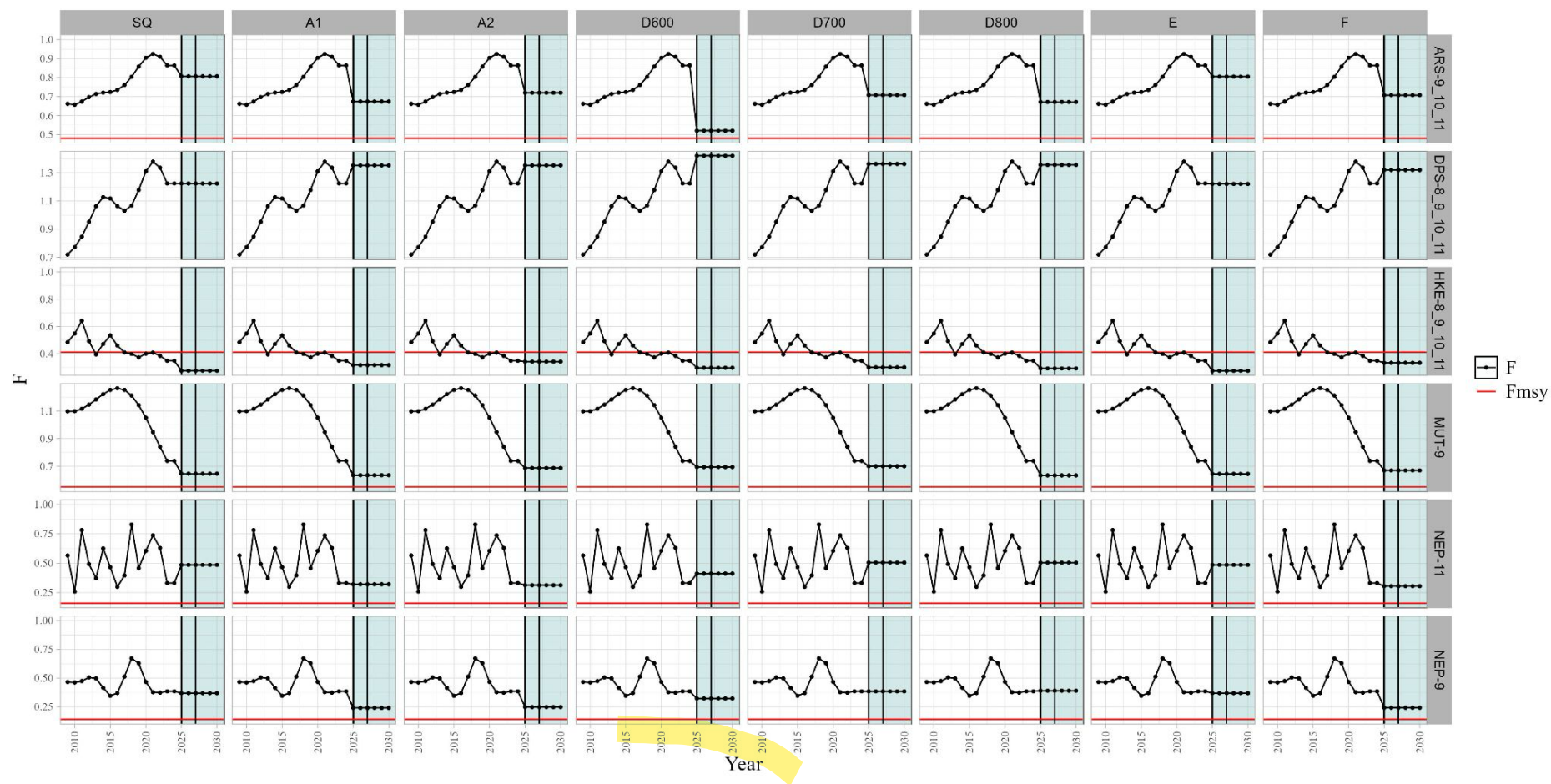
As far as HKE is concerned, all scenarios lead to a reduction in F and values lower than F_{MSY} .

Even in the case of MUT9, a sharp reduction in F is expected, approaching F_{MSY} but without reaching it.

In the case of NEP in GSA11, the SMART model returns very stable and flat trends, with reductions expected for Scenarios A and F (continuing the trend observed in recent years) and slight increases associated with the other scenarios, especially D.

Even in the case of NEP in GSA9, the SMART model returns very stable and flat trends, with reductions expected for Scenarios A and F (also compared to the values observed in recent years) and substantial stability in the other cases.

Figure 2 – Fishing mortality pattern for all the scenarios. Each panel displays the F value over the year, with F_{MSY} as the reference point.



Spawning Stock Biomass

Across most stocks (Figure 3), the *Status Quo* shows relatively stable but generally low SSB levels, often oscillating near or below precautionary thresholds (B_{pa}), suggesting that current exploitation rates maintain stocks at suboptimal levels with limited recovery potential. In contrast, all alternative management or effort reduction scenarios (A1–F) show marked improvements in SSB toward the end of the projection period, indicating that decreases in fishing mortality could substantially enhance stock status. The shaded projection period highlights a sharp divergence between scenarios, with reduced-effort or adaptive management options consistently producing higher median SSB values and narrower uncertainty ranges.

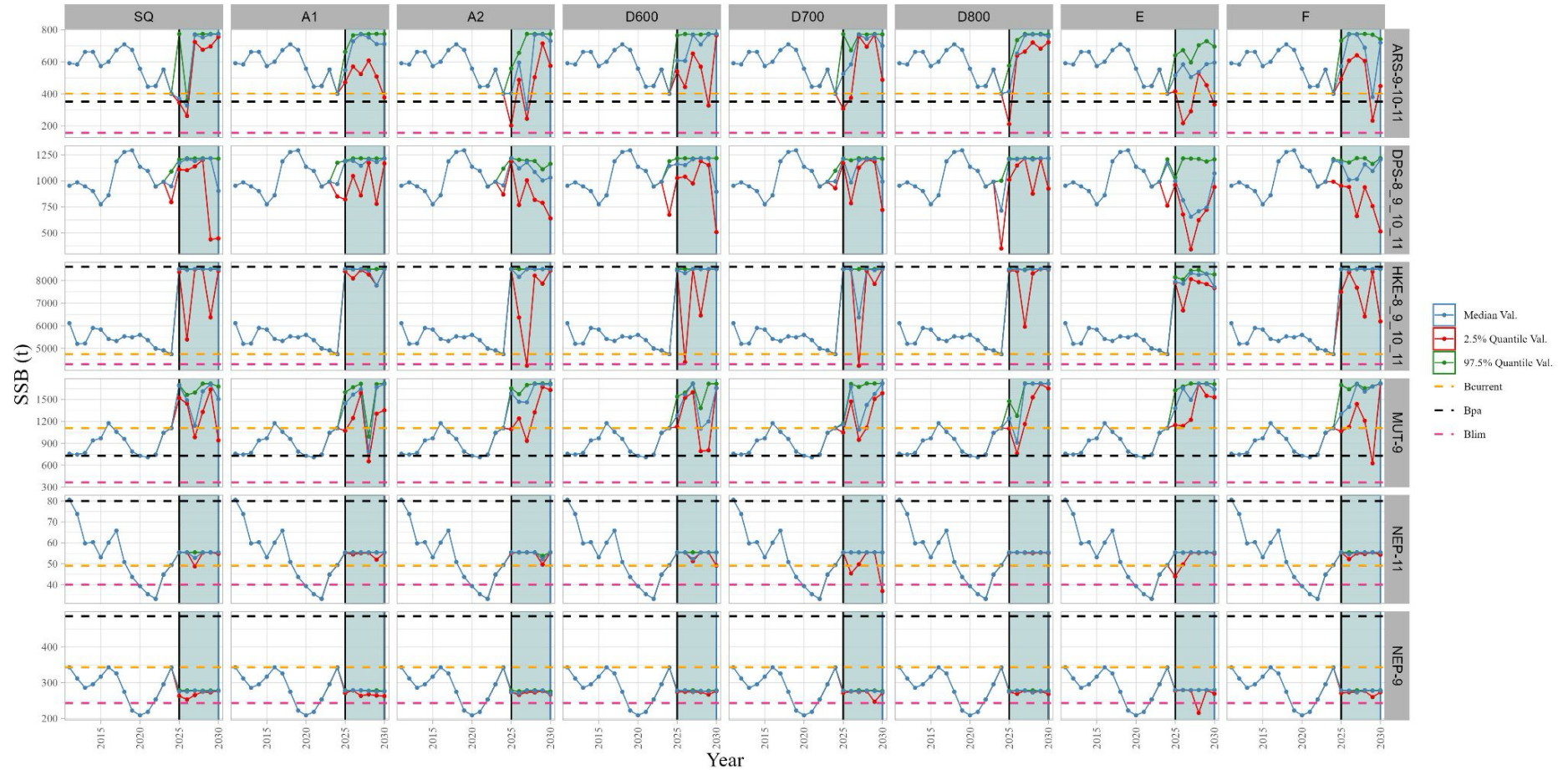
As regards ARS, the model forecasts (for the *Status quo*) sharp fluctuations in the short term, followed by a sharp increase in SSB, which will settle at high levels in the long term (2027–2030), much higher than B_{lim} . Similar trends are recorded in Scenarios A2 (with fluctuations in the medium term) and D800, but with a long-term upward trend. The other scenarios are associated with expected trends characterised by a gradual and steady increase in SSB. The only exception is Scenario F, which still forecasts an increase but with significant fluctuations in 2029.

The DPS stock experiences significant fluctuations in all scenarios except D800, which appears to be the one that guarantees the most immediate results. However, in all scenarios except the *Status Quo*, an improvement in the conditions of this stock is expected.

As regards HKE, all scenarios (including the *Status Quo*) predict a marked and stable improvement in the stock, which always reaches values close to B_{pa} . However, it is important to note that the very sharp increase in recruitment estimated in 2024 may have influenced the model. In almost all the scenarios, the 2.5% quantile shows strong fluctuations, indicating that there is considerable uncertainty about the future conditions of this stock. Better forecasts are linked to a reduction in compensation measures.

The MUT stock in GSA9 is the one whose forecasts show the greatest fluctuations. In many of the scenarios, there is a substantial improvement in stock conditions. The best forecasts are associated with Scenario A1 and Scenario E, which, however, was simulated only in the case of a reduction in compensation measures. However, it is interesting to note that, in both cases (in addition to what we saw with HKE), the reduction in compensation measures seems to stabilize the improving trend.

Figure 3. The figure illustrates the temporal trends in SSB for the different stocks under the range of management scenarios. Each panel displays the median (blue line) and uncertainty bounds (2.5% and 97.5% quantiles, in red and green, respectively) of projected SSB over the time, with biological reference points (B_{pa} and B_{lim}) marked for comparison.



According to the model, NEP stocks in GSA9 and 11 are those that respond least to management measures. In the case of NEP in GSA11, an improvement in stock conditions is still expected, with an SSB forecast to be higher than B_{curr} but still far below the B_{pa} value. In the NEP case in GSA9, a worsening of stock conditions is always expected, with a predicted SSB approaching B_{lim} .

Overall, the two sets of results are largely coherent: a reduction in fishing mortality (F) generally corresponds to an improvement in spawning stock biomass (SSB), confirming the expected biological link between exploitation pressure and stock recovery. All alternative management scenarios (A1-F) produce lower F values and higher SSB trajectories compared to the Status Quo (SQ), with the intensity of change depending on the intensity of effort reduction. Scenarios D-series (especially D600) tend to offer the strongest conservation outcomes, while SQ and E generally maintain higher fishing pressure and limited biomass recovery.

- ARS (GSA 9-10-11): All scenarios reduce F, with the largest effect in D600. Correspondingly, SSB exhibits sharp and sustained increases, reaching well above B_{lim} and often exceeding B_{pa} in A2 and D800.
- HKE (GSA 8-9-10-11): Every scenario - including the *Status Quo* - leads to a decline in F below F_{MSY} , and to steady SSB growth towards or near B_{pa} . The very sharp recruitment increases projected for 2024 may partly amplify this trend, but the overall consistency between F and SSB trajectories remains robust.
- MUT (GSA 9): F sharply decreases under most scenarios, approaching F_{MSY} but not falling below it. The corresponding SSB trajectories are more variable, yet still show improvements under A1 and E, the same scenarios identified as beneficial in the F analysis.
- NEP (GSA 9 and GSA 11): In both NEP stocks, the model indicates very stable and flat F trends, with slight reductions only under Scenarios A and F. This stability is comparable to the SSB projections: NEP in GSA11 shows modest improvement, while NEP in GSA9 exhibits a decline toward B_{lim} .

Some localized inconsistencies emerge when comparing specific stock–scenario combinations:

- ARS (GSA 9-10-11): Although both indicators show consistent improvement, the SSB trajectories under SQ rise sharply despite F values remaining relatively high. This could point to an over-optimistic projection in the biomass model or delayed demographic effects. However, as noted by some experts during the EWG, it is possible that current mortality values for these stocks are already relatively low and could be increased.
- DPS (GSA 8-9-10-11): The F analysis identifies SQ and E as those achieving the largest mortality reductions, while Scenarios D and F may even cause slight increases in F. However, the SSB results indicate an improvement under almost all scenarios except SQ, with D800 performing best. Maybe, DPS may respond to other mechanisms (e.g.,

recruitment variability or compensatory dynamics) not directly reflected in F projections.

- MUT (GSA 9): While both F and SSB results show a general improvement, the magnitude and variability differ. SSB outcomes fluctuate considerably among scenarios, whereas F reductions are more uniform. This could indicate high uncertainty in stock-recruitment relationships or sensitivity to short-term recruitment events.

Catch

Table 3 presents the projected catches for 2026 under different management scenarios, based on STECF 25-09 outputs, and compares them with the single-stock catch advice. Overall, catch patterns are consistent with the expected effects of varying fishing mortality (F), showing that scenarios with stronger reductions in F generally produce lower or more moderate catches, while scenarios maintaining higher exploitation rates yield higher short-term landings.

Scenarios D600-D800, associated with the greatest reductions in F , often correspond to intermediate or reduced catches, while Status Quo (SQ) and Scenario E, which maintain higher F , typically generate higher or more variable catch levels in 2026. This inverse relationship between F and catch is not uniform, however, due to stock-specific biological responses and recruitment variability.

- ARS (9-10-11): Projected catches range well above the single-stock advice. The lowest catch is predicted under D600, the scenario showing the strongest decrease in F , while the highest corresponds to Scenario F, which maintains relatively higher F . This pattern aligns closely with the mortality projections: stronger conservation measures (lower F) reduce short-term yields but favor rebuilding potential. Scenarios A1, A2, and D800 produce intermediate catches, consistent with the moderate F levels described previously.
- DPS (8-9-10-11): Catch projections show considerable variability and partial inconsistency with F trends. The highest catch (Scenario D600) coincides with one of the scenarios predicted to increase F , while Scenario E, which previously showed a decrease in F , also yields high catches. This suggests that the stock's response is driven by short-term recruitment fluctuations or biomass availability rather than purely by fishing pressure. The lowest catch (Scenario D700) aligns with stronger effort limitations, while Status Quo remains close to the current exploitation pattern.
- HKE (8-9-10-11): Hake catches show a wide range. Interestingly, D700 and D600 yield the highest catches, despite being associated with reduced F in the previous analysis. This apparent inconsistency likely reflects biomass recovery following past reductions in F , which allows higher sustainable yields even under conservative management. Conversely, A1, A2, and F exhibit lower catches, suggesting a temporary dip in yield due to reduced fishing effort before the stock fully rebuilds.

- **MUT (GSA9):** Catch projections are relatively stable, indicating limited sensitivity to management changes. The highest catch (Scenario F) coincides with the highest F, while the lowest catches occur under A1 and A2, consistent with lower F levels. Overall, MUT shows a predictable and coherent pattern, where moderate F reductions lead to modest catch losses, aligning with the smoother F-SSB dynamics discussed earlier.
- **NEP (GSA9):** Catches vary moderately; the lowest occurs under Scenario F, which corresponds to one of the lowest F values, while D700 and E produce higher catches, consistent with slightly higher F. However, given the previously observed flat F trends and limited responsiveness of this stock, these variations are likely within the range of model uncertainty.
- **NEP (GSA11):** Catches mirror the F trends almost perfectly: the lowest catches occur under Scenario A2 and F, both associated with reduced F, whereas SQ and D800 yield the highest catches, reflecting sustained exploitation. This pattern supports the interpretation that NEP in GSA11 maintains stable but low biomass levels, responding predictably - though slightly - to effort reductions.

Table 3 Total catches by management scenarios for 2026 for single-stock advice (based on STECF 25-09 outputs) and scenarios

Stock	Catches per scenario 2026 (in tons)							
	SQ	A1	A2	D600	D700	D800	E	F
<i>ARS-9_10_11</i>	425	750	702	541	629	742	667	801
<i>DPS-8_9_10_11</i>	3226	3322	2847	4451	1786	3079	3882	2150
<i>HKE-8_9_10_11</i>	88418	36162	38993	95410	98949	88759	88159	37226
<i>MUT9</i>	1357	1171	1173	1343	1281	1329	1203	1373
<i>NEP9</i>	352	254	236	325	367	355	358	230
<i>NEP11</i>	115	78	77	96	115	118	112	74

The combined interpretation of F, SSB, and catch results highlights **three main response patterns**:

1. Direct F-Catch Coupling (ARS, MUT, NEP 11):

Stocks where catch magnitude directly reflects changes in F, indicating immediate

sensitivity to effort control.

2. Lagged or Compensatory Dynamics (HKE, DPS):

Stocks showing high catches despite reduced F, due to biomass recovery or recruitment pulses that decouple short-term yields from current F levels.

3. Low-Response Stocks (NEP 9):

Species with limited responsiveness, possibly due to biological traits (slow growth, stable populations) or model insensitivity.

Table 4 reports the projected total catches for 2030 under the same management scenarios. When compared with 2026, most stocks exhibit clear signals of biomass recovery and stabilisation, leading to lower variability across scenarios and, in some cases, increased compatibility with single-stock advice levels. Overall, the long-term projections highlight that the benefits of reduced fishing mortality (F) begin to materialise through higher or more stable yields, particularly for stocks that had shown rebuilding dynamics in earlier years.

Table 4 Total catches by management scenarios for 2030 for single-stock advice (based on STECF 25-09 outputs) and scenarios

Stock	Catches per scenario 2030 (in tons)							
	SQ	A1	A2	D600	D700	D800	E	F
ARS-9_10_11	731	529	624	522	577	632	550	572
DPS-8_9_10_11	3005	3306	2465	3348	2133	4160	3588	2520
HKE-8_9_10_11	17978	12645	13432	19462	19700	19125	17727	13135
MUT9	720	822	866	756	735	724	776	864
NEP9	1089	760	731	999	1115	1100	1089	710
NEP11	194	128	121	150	196.79	189	189	119

By 2030, the relationship between F and catch becomes more coherent and biologically consistent. Scenarios D600-D800, which enforce stronger reductions in F, yield equal or higher catches compared with short-term projections, indicating that biomass recovery has translated into sustainable yield gains. Conversely, *Status Quo* and Scenario F, which maintain higher exploitation rates, tend to produce lower catches than in 2026, reflecting the long-term depletion effects of sustained fishing pressure. This inversion of short-term patterns confirms

that conservative management, though costly initially, delivers more productive and stable fisheries in the medium term. Specifically:

- **ARS (9-10-11):** Catches in 2030 are generally lower than in 2026. The spread between scenarios is narrower, suggesting that the stock stabilises under multiple management strategies.
- **DPS (8-9-10-11):** The stock continues to show large variability, but the overall catch levels remain close to the 2026 range, with Scenario D800 again producing the highest catches. This suggests that, despite fluctuating biomass, a moderate reduction in F allows higher yields by 2030.
- **HKE (8-9-10-11):** Hake displays the clearest recovery signal. Despite the lower single-stock advice compared with 2026, the D600-D800 scenarios yield the highest catches, outperforming SQ. This confirms that lower F in earlier years allowed biomass to rebuild, translating into higher sustainable yields by 2030. Scenarios A1-A2 and F, which maintain higher F, now deliver substantially lower catches, demonstrating the cumulative negative effect of sustained exploitation.
- **MUT (GSA 9):** Catches remain within a narrow range, slightly lower than in 2026. Scenarios A1-A2 and F show the highest catches, consistent with their higher F levels. However, the differences between scenarios are minimal, suggesting a relatively stable or saturated population that does not respond strongly to further reductions in effort.
- **NEP (GSA 9):** Catches in 2030 increase substantially compared with 2026, reflecting a marked biomass recovery and possibly a more favourable productivity regime. The highest catches occur under Scenarios D700, D800 and E, coinciding with intermediate F levels, while Scenario F underperforms due to cumulative depletion. This shift confirms that long-term rebuilding under reduced F can restore productive capacity.
- **NEP (GSA 11):** Catches increase moderately compared to 2026. The highest yields correspond to D700-D800. Lower F scenarios now support optimal yields, indicating that this stock has stabilised at or near sustainable levels.

The 2030 projections confirm that rebuilding trajectories initiated under D600–D800 scenarios lead to sustainable and sometimes higher yields after a few years. Scenarios maintaining higher F (E, F, and SQ) consistently underperform, emphasizing that proactive reductions in fishing mortality are both ecologically and economically advantageous in the medium term. In synthesis:

- Stocks such as HKE, NEP 9, and NEP 11 show tangible long-term benefits from effort reduction.
- DPS remains variable but maintains resilience under moderate F.
- ARS and MUT display stability, suggesting that management measures can be fine-tuned without major yield losses.

Table 5 Fishing Mortality (F) by management scenarios for 2026 for single-stock advice (based on STECF 25-09 outputs) and scenarios

Stock	F(2026) resulting from scenario							
	SQ	A1	A2	D600	D700	D800	E	F
ARS-9_10_11	0.81	0.67	0.72	0.52	0.71	0.67	0.81	0.71
DPS-8_9_10_11	1.22	1.35	1.35	1.42	1.36	1.36	1.22	1.32
HKE-8_9_10_11	0.27	0.32	0.34	0.30	0.30	0.29	0.27	0.33
MUT9	0.65	0.64	0.69	0.69	0.70	0.63	0.64	0.67
NEP9	0.37	0.24	0.25	0.32	0.38	0.39	0.37	0.24
NEP11	0.49	0.32	0.31	0.41	0.51	0.50	0.49	0.30

Legend:

	F2026 < Fmsy
	Fmsy < F2026 < Fpa
	F2026 > Flim

Table 6 Spawning stock biomass (SSB) by management scenarios for 2026 for single-stock advice (based on STECF 25-09 outputs) and scenarios

Stock	SSB(2026) resulting from scenario							
	SQ	A1	A2	D600	D700	D800	E	F
ARS-9_10_11	326	727	595	606	584	652	583	772
DPS-8_9_10_11	1207	1191	1119	1150	984	1206	813	1008
HKE-8_9_10_11	8470	8482	8158	8323	8499	8500	7858	8460
MUT9	1488	1567	1468	1566	1673	910	1653	1398
NEP9	252	278	265	274	275	268	279	273

<i>NEP11</i>	55	55	55	55	55	55	55	54
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Legend:

	SSB2026 > Bpa
	Blim < SSB2026 < Bpa
	SSB2026 < Blim

Table 7 Spawning stock biomass (SSB) by management scenarios for 2030 for single-stock advice (based on STECF 25-09 outputs) and scenarios

Stock	SSB(2030) resulting from scenario							
	SQ	A1	A2	D600	D700	D800	E	F
<i>ARS-9_10_11</i>	771	710	730	772	699	758	595	719
<i>DPS-8_9_10_11</i>	902	1214	1030	894	992	1216	1071	1202
<i>HKE-8_9_10_11</i>	8484	8504	8488	8504	8502	8504	7709	8503
<i>MUT9</i>	1505	1709	1707	1657	1721	1717	1640	1717
<i>NEP9</i>	277	262	267	276	271	268	269	273
<i>NEP11</i>	55	55	55	55	55	55	55	55

Legend:

	SSB2026 > Bpa
	Blim < SSB2026 < Bpa
	SSB2026 < Blim

2) Socio-economic outputs for all West Med stocks

As in previous years since 2022, the scenarios' socio-economic outputs should be summarized in a table with estimates in 2026 (short-term) and by 2030 (mid-term), for each fleet segment and each Member State the landings of the main stocks could be used to calculate the socio-economic indicators:

Table 8. Synthesis table for scenarios

Scenarios	MS	Estimated level of F for target species in 2026	Estimated level of F for target species in 2026, resp. 2030	Estimated % landings of target species change 2020-2026	Estimated % landings of target species change 2020-2026, resp. 2030	Estimated % variation of profitability (gross profit margin) 2025-2026 and 2020-2026	Estimated % variation of profitability (gross profit margin) 2025-2026 and 2020-2026	Estimated % variation of FTE on-board 2020-2026	Estimated % variation of FTE on-board 2020-2026, resp. 2030	Estimated % Gross profit margin 2020-2026, resp. 2030	Estimated % variation of FTE on-board 2020-2026, resp. 2030
SQ	IT	120.0	115.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A1	IT	110.0	105.0	4.5	1.2	0.9	0.2	2.2	0.6	0.2	0.2
A2	IT	100.0	95.0	132.0	34.3	26.4	6.9	66.0	17.1	6.9	6.9
D600	IT	90.0	88.0	135.0	33.6	33.0	12.7	67.5	16.8	12.7	12.7
D700	IT	93.0	91.0	116.7	41.2	27.3	12.2	58.4	20.6	12.2	12.2
D800	IT	98.0	96.0	116.2	30.5	25.2	8.1	58.1	15.2	8.1	8.1
E	IT	115.0	110.0	0.3	-1.4	0.1	-0.3	0.1	-0.7	-0.3	-0.3
F	IT	118.0	113.0	112.9	32.8	22.6	6.6	56.5	16.4	6.6	6.6

Table 8 summarises projected socio-economic outcomes for Italian fisheries under the management scenarios considered (2026–2030). Fishing mortality (F) values are expressed as percentages of FMSY, showing that the most precautionary scenarios (D600–D800) achieve the lowest exploitation levels. Percentage changes in landings, profitability, and employment (FTE) are computed relative to the Status Quo (SQ) using total catch value variations as a proxy. Profitability and the number of fleet segments operating under viable conditions ("in green") increase substantially in D-series scenarios, reflecting cost reductions and improved biological status of key stocks. By 2030, the effects stabilise, with D700 emerging as the scenario combining strong profitability and sustainable exploitation levels.

References

- Ban C, Vincent A. (2009). Beyond marine reserves: exploring the approach of selecting areas where fishing is permitted, rather than prohibited. *PLoS One* 2009;1–8. <https://doi.org/10.1371/journal.pone.0006258>
- D'Andrea L., Parisi A., Fiorentino F., Garofalo, G., Gristina, M., Cataudella, S., Russo, T. (2020). smartR: An R package for spatial modelling of fisheries and scenario simulation of management strategies. *Methods Ecol Evol.*, 11: 859-868. <https://doi.org/10.1111/2041-210X.13394>
- Fabbrizzi, E., Giakoumi, S., De Leo F. (2022). The challenge of setting restoration targets for macroalgal forests under climate changes. *J Environ Manage* 2023; 326:116834. <https://doi.org/10.1016/j.jenvman.2022.116834>
- Hanson, J.O., Schuster, R., Morrell, N. (2023). prioritizr: systematic conservation prioritization in R. CRAN, 2023. <https://cran.r-project.org/web/packages/prioritizr/index.html>. Accessed on 23/11/2023.
- Russo, T., Parisi, A., Garofalo, G., Gristina, M., Cataudella, S., & Fiorentino, F. (2014). SMART: A Spatially Explicit Bio-Economic Model for Assessing and Managing Demersal Fisheries, with an Application to Italian Trawlers in the Strait of Sicily. *PLOS ONE*, 9(1), 1-18. <https://doi.org/10.1371/journal.pone.0086222>
- Russo, T., Morello, E.B., Parisi, A., Scarcella, G., Angelini, S., Labanchi, L., Martinelli, M., D'Andrea, L., Santojanni, A., Arneri, E., Cataudella, S. (2018). A model combining landings and VMS data to estimate landings by fishing ground and harbor. *Fisheries Research*, Volume 199, 218-230, ISSN 0165-7836. <https://doi.org/10.1016/j.fishres.2017.11.002>.
- Russo, T., D'Andrea, L., Franceschini, S., Accadia, P., Cucco, A., Garofalo, G., Gristina, M., Parisi, A., Quattrocchi, G., Sabatella, R. F., Sinerchia, M., Canu, D. M., Cataudella, S., Fiorentino, F. (2019). Simulating the Effects of Alternative Management Measures of Trawl Fisheries in the Central Mediterranean Sea: Application of a Multi-Species Bio-economic Modeling Approach. *Frontiers in Marine Science*, 6. <https://doi.org/10.3389/fmars.2019.00542>
- Sala, A., Damalas, D., Labanchi, L. *et al.* (2022). Energy audit and carbon footprint in trawl fisheries. *Sci Data* 9, 428. <https://doi.org/10.1038/s41597-022-01478-0>
- Sbrana, A., Galli, S., Casini, M., Carlucci, R., Dassenakis, M., Fiorentino, F., Follesa, M.C., Garofalo, G., Georges, V., Isajlovic, I., Klancnik, K., Lauria, V., Maiorano, P., Manfredi, C., Mavric, B., Pagou, K., Papadopoulou, N., Paramana, T., Paraskevopoulou, V., Pulcini, M., Rakaj, A., Ronchi, F., Sabatella, E.C., Scarcella, G., Smith, C.J., Stefani, M., Streftaris, N., Tassetti, A.N., Yahyaoui, A., Vrgoc, N., Raicevich, S., Russo, T. (2025). Exploring spatial-based management

scenarios to protect the seafloor in different areas of the Mediterranean Sea. ICES Journal of Marine Science, 82, 3,fsaf023. <https://doi.org/10.1093/icesjms/fsaf023>